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VOL. XXXIV. JUNE-AUGUST, 1927. Nos. 3-4

A STUDY OF THE MALE ABDOMINAL APPENDAGES OF THE NAIS-GROUP OF APANTESIS WALKER. (LEPIDOPTERA ARCTIIDÆ)

By Elmer T. Learned, M. D.
Fall River, Mass.

The genus Apantesis is composed of moths well known for their variability, a character especially marked in the four forms: *nais* Drury, *vittata* Fabricius, *radians* Walker, and *phalerata* Harris. The close relationship of these moths suggested that it would be interesting to examine the male abdominal appendages in a series, to see to what extent these organs vary, and whether constant structural differences exist between the forms as separated by superficial characters. Before considering the genitalia I propose to summarize briefly what is now known about these moths.

The range of variation in these insects is so wide that it is impossible to give a description which will always serve to distinguish one form from all its allies. Each tends toward a certain characteristic type, however, and in spite of the similarity in markings the moths are readily separable into the four forms. With a knowledge of the habitus of each form and appreciation of the factors which are apt to vary it in one or another direction, only old or worn specimens and occasional extreme variations should cause confusion.

Nais includes specimens predominantly yellow in color, comparatively robust thorax with rough vestiture, the collar most often immaculate, the pattern of the forewings usually complete or nearly so, always with black costal edge; the hind

wings sometimes tinged with red, the black spots discreet, rarely fused or absent.

In *vittata* the pattern of the fore-wings usually lacks the W mark, and the costa is pale. A character sometimes useful is a tendency to a more evenly rounded outer margin of the fore-wings, giving them a broad and stumpy appearance. The hind-wings are usually red, sometimes yellow, the black spots often fused. The dorsum of the abdomen may or may not be broadly black.

A brood of *vittata* which I reared recently thru two generations appears to be a mutation. All the moths of the first generation had a black costal margin on the fore-wing, instead of the pale one usual to *vittata*, and the male appendages showed a constant difference from the normal form thruout both generations.

Radians is closest to *phalerata* in appearance, but the pattern of the fore-wings is usually abbreviated as in *vittata*, with pale costa. The hind-wings are typically yellow tinged with red, exactly as in *phalerata*, and similarly the red may be entirely lacking, or may predominate. I include under *radians* the form *floridana* Cassino, and regard this name as a synonym. The female *floridana* does not differ from the form which has always been regarded as *radians*, and the male agrees with the description and figures of the male which Seifert first associated with *radians* by breeding.

Phalerata is the most protean of the four forms. While in most cases easily recognized, its variations may almost exactly resemble any of the other forms. The pattern of the fore-wings is usually complete, but is often more or less abbreviated and the costa may be either black or pale. The fore-wings tend to be comparatively narrow, particularly as compared to *vittata*, with the outer border more oblique with well marked apex. The hind-wings vary from the typical yellowish tinged with pink at the inner margin, to pale yellow or red. The abdomen is more frequently tinged with reddish on the sides than in the other forms.

There is a form of *phalerata*, apparently common in Florida, and which I also have from Alabama and Arkansas, which has

the pattern of the fore-wings complete, and the hind-wings immaculate (except for black along the costa) and varying from the bright pinkish to pale yellow in color. This form is particularly mentioned because of its resemblance to both *nais* and *radians*.

The females of three of the four forms are even more similar than the males. *Nais* is distinguished from *vittata* by its black costal margin, while *vittata* and *radians* differ only in the extent of the markings of the fore-wing, and grade into each other. The female *phalerata* stands apart with a more complete pattern on the fore-wings and a broken border on secondaries. I find, moreover, a small but constant difference from the other three forms in the female genitalia.

Life histories of *nais* and *radians* have been published by Seifert, and of *phalerata* by Gibson. So far as I have been able to discover, no life history of *vittata* has been published; brief descriptions of the adult larva occur in papers by Dyar, and by Gibson. A few descriptions of larvæ were published by earlier writers, but are too generalized to be of much value, for the larvæ of this group are so similar that descriptions must be minute to be of use for comparisons. The larvæ are as variable as the moths, and in the same brood may vary in the presence or absence of a dorsal line or other marking, in their color, and in the color of the lateral setæ. Gibson could see no difference between the larvæ of *nais* and *phalerata*. Other descriptions, however, imply that the larvæ of all the forms differ. They are probably not yet well enough known to permit definite conclusions in regard to them.

The similarity of the moths of the *nais*-group has caused some difference of opinion as to whether they are all forms of one species or four distinct species. I have found nothing in the literature to show that one form has ever been bred from another, aside from statements unsupported by evidence, and one instance where it appears that mistaken identification has caused confusion. On the other hand, reports of observers with experience of several broods indicate that the forms breed true. Seifert reared a number of broods of *nais* and experimented with temperature effects on the pupæ. He also reared *radians* thru two generations, and attempted to mate females by exposing

them in localities about New York where *vittata* was known to occur, but without success. This appears significant, but the possible effect of climatic difference on fertility must be considered. Marchand concluded that *nais, vittata* and *phalerata* were distinct species; he reared several broods of *nais* and *phalerata* which always bred true. His attempt to cross these moths was unsuccessful as would be expected from the genitalic differences, which he notes.

It is not necessary to assume that interbreeding must occur to explain occasional extraordinary resemblances between these forms. Variability is inherent in living organisms, and since the characters which vary in these moths are the same in all, any departure of a form from its normal mean makes it approaach one of the other forms. Also, in closely related forms apparently recently differentiated the occurrence of atavism may explain some of the intergrading individuals.

There is nothing in the literature on the genitalia of Apantesis with the exception of a brief paper by Dyar in which he figures the claspers and tegumen of *nais*, *vittata*, and *phalerata*. Dyar concluded that *phalerata* was a good species, but later placed it as a variety of *vittata* in his catalog.

The species of Apantesis as a whole show a wide range in the form of the male abdominal appendages. The moths of the *nais* group differ in common from the other species which I have examined. The ædoeagus in other species than those of the *nais* group is evenly and moderately chitinized thruout, except for occasional thickening near the orifice, and is unarmed. In the *nais* group this organ has a part of the circumference of the distal half thickened and heavily chitinized, and armed with one or more stout spines. I find no name in the literature which seems to apply to this localized area of thickened chitin in the ædoeagus, and will refer to it as the *callum* ("thickened skin"). In this thickening and armature this group resembles other Arctiidæ, in some of which the ædoeagal armature is highly developed.

The claspers are inwardly concave, roughly quadrilateral in shape, with an arm arising from the upper edge and projecting inwardly toward that of the opposite clasp. The distal portion of the clasper is composed of two distinct layers of chitin; the

free edge of the inner layer is sharply defined. The lower border of the clasp is excavated near its middle, proximal to which it curves inward. This inward curve becomes more marked in prepared specimens, and as it is impossible to flatten the clasp without distorting it, the drawings show this part of the lower edge upturned.

The uncus consists of a broad basal part which joints the tegumen, and distally becomes spear-shaped as seen from above, beak-like laterally. There is a deep groove where the broad base of the uncus joins the tegumen, which is hardly noticeable from above. The ventral half of the tegumen shows no characteristic differences in the group, except that it is narrower and more pointed in *radians* and *phalerata*. The juxta in the *nais*-group as seen from below appears cone-shaped, and projects from the manica. In other species of the genus it consists of a thickening of the manica which remains closely apprest to the ædoeagus.

The organs are so curved, especially the claspers that great care is necessary in making comparisons, for a slight difference in orientation will make a great difference in the apparent shape of the organ. For this reason the usual balsam mounts were found unsatisfactory in this study, and after preparing the genitalia in the usual way and studying the structures as a whole the componene organs were dissected apart and compared unmounted. Before beginning the study of the genitalia the specimens were sorted into the different groups on superficial characters. The genitalia of seventeen specimens of *nais* were examined, twenty-one of *vittata*, (besides seventeen of the aberrant brood), eight of *radians*, (including *floridana*), and fifty of *phalerata*. All the *radians* were from Florida; the other series included moths from various localities. Each series included specimens showing wide variations in maculation.

A. nais (Figs. 1-7). The usual form of the clasper is shown in Fig. 2. Variations occur in the relative length and width of the part, the length of the rounded apex, and the degree of curvature of the posterior (distal) edge. Fig. 3 shows a clasper in which all these variations appear. In all the species variations occur in the size and shape of the costal arm, the extent of the

the lower border, and are of no significance. The basal part of the uncus tends to be a little rounded at the sides, but this varies, as does its width. Fig. 5 shows an average specimen; in others the spear-head may be shorter and broader, or it may be narrower. The juxta resembles a bisected cone, the flat surface against the manica, and varies much in length and breadth; in most specimens it is evenly tapered to a rounded point, but in two the end is broad and blunt. Figs. 6 and 7 illustrate two extremes.

The ædœagus is similar in shape to *vittata* and *radians*, consisting of an irregular chitinous tube with a slight double curve in the sagittal plane, the duct entering thru its dorsal surface just distal to the base. Size and details of shape and curvature are subject to individual variation in all the species. On the right lower lateral and extending partly onto the ventral aspect of the distal portion is the area of heavy chitinization which I have called the callum. Distally it is produced into a stout, hook-like spine, which points at right angles to the axis of the ædoeagus, and the whole hook-like structure is sharply bent laterally. The callum tapers proximally, and the proximal part becomes twisted nearly at right angles to the distal portion due to the upturning of the lower edge, and is often curved toward the dorsum. This peculiarity is particularly well marked in the specimen selected for Fig. 1. The distal edge of the callum forms part of the boundary of the orifice, and the vesica is attached to it; elsewhere the callum blends into the normal chitin. Wide variations are found in the length and width of the callum, and in the size and shape of the spine; in all the specimens examined, however, the proximal portion showed the characteristic twist. One aberration was found with small callum and a bifurcate spine (Fig. 4). *Nais* showed a much smaller range of variation in the genitalia than the next species.

A. vittata (Figs. 8-16) bears an exceedingly close resemblance to *nais* in the genital structures. The variations in claspers, uncus, and juxta in each species grade into each other so that it is often impossible to tell from one organ alone to which species it belongs. The claspers of *vittata* vary along the same lines as those of nais, but the range of variation is greater. The average form of clasp is shown by Fig. 13. Its close similarity to that of

nais is seen by comparing Fig. 2. A more definite angle at the junction of the posterior and upper margins in *vittata* is the only difference, (the shape of the costal arm and of the lower border is of no importance) and sometimes serves to distinguish them, but is not constant. The specimen in Fig. 9 (which happens to be from a large moth) has as evenly curved a posterior edge as has *nais*. The other extreme is shown in the clasp with flattened, oblique, posterior margin (Fig. 16). The uncus is similar to that of *nais* and varies to the same extent. The basal part tends to be less rounded in *vittata* with the sides more sloping, but Figs. 5 and 12 were selected to show the different forms, and are not intended to imply a constant, specific difference. The usual form of the juxta is shown in Fig. 10. It varies in length and in three specimens was as long as in *nais*, (Fig. 11).

The ædoeagus is similar to *nais*, but thruout the series a constant difference was found in the callum. It differs from *nais* in the proximal end, which flattens out and blends into the normal chitin, while in *nais* this end becomes twisted. There is more variation in *vittata* in the shape of the spine, several variations of which are shown (Figs. 8, 14, 15); one specimen was found with a long, bifurcated spine. Fig. 15 shows the closest approach to *nais* found in the series, in the short, broad callum (the shape of the spine is not important) but the proximal end shows the difference noted.

Figs. 17-21 are from specimens of the aberrant brood of *vittata* mentioned above. The same peculiarities were found in two generations. The claspers are not distinctive. Tho relatively long and narrow, with an unusually broad arm, they are probably within the range of variation of *vittata*. The uncus is remarkably different, having the spear point nearly twice as long as in any other form, and with prominent rounded "shoulders" on the basal part. It was the same in all the specimens examined. The juxta has a broad, blunt end. The ædoeagus differs from the normal *vittata* in the absence of the lateral bend of the distal portion of the callum, and has two diverging, nearly equal spines. Two specimens were exceptional in having but one spine, thus resembling normal *vittata*. The occurrence of a double or bifurcate spine as an aberration

in both *nais* and *vittata*, is interesting as showing a tendency which has become fixt in the next two forms.

In *radians* (Figs. 22-28) the claspers show a strong tendency to a very oblique posterior margin (Fig. 23.) This resembles an extreme form of *vittata* (Fig. 16), but the obliquity is greater in *radians*. One specimen, however, (Fig. 28) is similar to both *nais* and *vittata*. The uncus does not differ much, if at all, from *nais* and *vittata*. The slight difference is found in a shorter and broader spear-head. The juxta has a flat, broad tip, and resembles that of the aberrant form of *vittata*, a form also found in *nais*. The ædoeagus shows a characteristic peculiarity in having multiple spines—two specimens had four spines (Fig. 22), five specimens had three spines (Fig. 27), and one had but two, (Fig. 26). The callum resembles that of *vittata*, but the distal part is broader, and lacks the lateral bend, being drawn out into a strong spine; above this main spine are smaller ones, diminishing in size dorsally. In the specimen with only two spines, they are nearly equal, the second one abnormal in being directed posteriorly.

A. *phalerata* (Figs. 29-38) differs remarkably from other members of the group, and is unique in the form of the claspers and ædoeagus. The clasper is of unusually large size and exceeds that of the largest species of the genus, *A. virgo*. Individual variations are slight, and consist in differences in length and shape of the terminal projection, and in the degree of angulation of the upper edge; Fig. 32 shows an extreme form in which one angle is completely flattened out. A slight asymetry is sometimes found between the clasps of opposite sides. The uncus differs from the other species in the longer and narrower spear-head, with evenly curved edge, and the basal portion is also relatively long and narrow. The juxta, seen from below (Fig. 33), is flattened at the base while the distal part is comprest laterally more narrowly than in the other moths, so that it forms a keel-like projection. There is little individual variation in either uncus or juxta.

The ædoeagus is distinctive. The thick, heavily chitinized area covers nearly the whole of the right side of the distal half, curving onto the ventral side and over the distal end, forming a

sort of three sided investment. At its apical angle it is produced into two slightly diverging stout conical spines; proximally it tapers into a narrow ridge. In the figure a large portion of the callum is obscured, being overlapped by other parts. The ædoeagus of *phalerata* is unique not only in external structure, but the vesica also differs in form from that of the other moths of the group. The ædoeagus was found to be variable in regard to the terminal spines, about one out of every four specimens examined showing some departure from the normal evenly bifid structure; such variation ranged from a slight irregularity in size of the spines to complete absence of a spine on one hand, and on the other the addition of a third spine; the presence of a third spine appears to be due to the bifurcation of one of the existing spines, rather than the production of a new one. Several such aberrations are shown in Figs. 35-38.

The moths used in this study were sorted into four groups before beginning the study of the genitalia and the structural differences were found to correspond with the separation on superficial characters, with two exceptions. One specimen was included under *phalerata* which structurally proved to be *radians*, and a specimen of *vittata* was also found under *phalerata*. Each of these specimens was atypical in maculation and represented a borderline variation; the genital structures, however, were perfectly typical. It is worth noting that while *phalerata* is the most protean of the forms and most apt to cause confusion by the similarity of its variations to the other forms, it differs the most in structure. In making determinations it is necessary only to remove a few hairs to expose the long narrow terminal projection of the clasper characteristic of *phalerata*. With *phalerata* eliminated, of the remaining three forms *nais* is recognized by its black costa, while *vittata* and *radians* usually differ in the coloration of the hind wings.

Nais and *vittata* are found to be very similar structurally but a constant tho slight difference occurs in the ædoeagus. *Radians* differs from them in the multiple spines of the ædoeagus, and for the most part the claspers are characteristic tho they may resemble *vittata*. Study of a larger series of *radians* would be desirable. *Phalerata* shows a surprising degree of divergence from

its allies, all the genital structures being unique, including the vesica. The variations of the genitalia which occurred within each form were found to be independent of variations in maculation, nor did they bear any relation to locality.

No one factor, structural or otherwise, can determine a species, and more knowledge of the early stages, bred thru more than one generation, is essential to a thoro knowledge of any form. As our knowledge stands at present, however, I believe the evidence indicates that all of the forms are species. We have four forms readily separable on superficial characters and with corresponding structural differences, no one of which is known to have been bred from the other. It seems more logical to regard such forms as distinct until proved otherwise, than to lump three of them under one species as at present.

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Explanation of Plates IV and V.

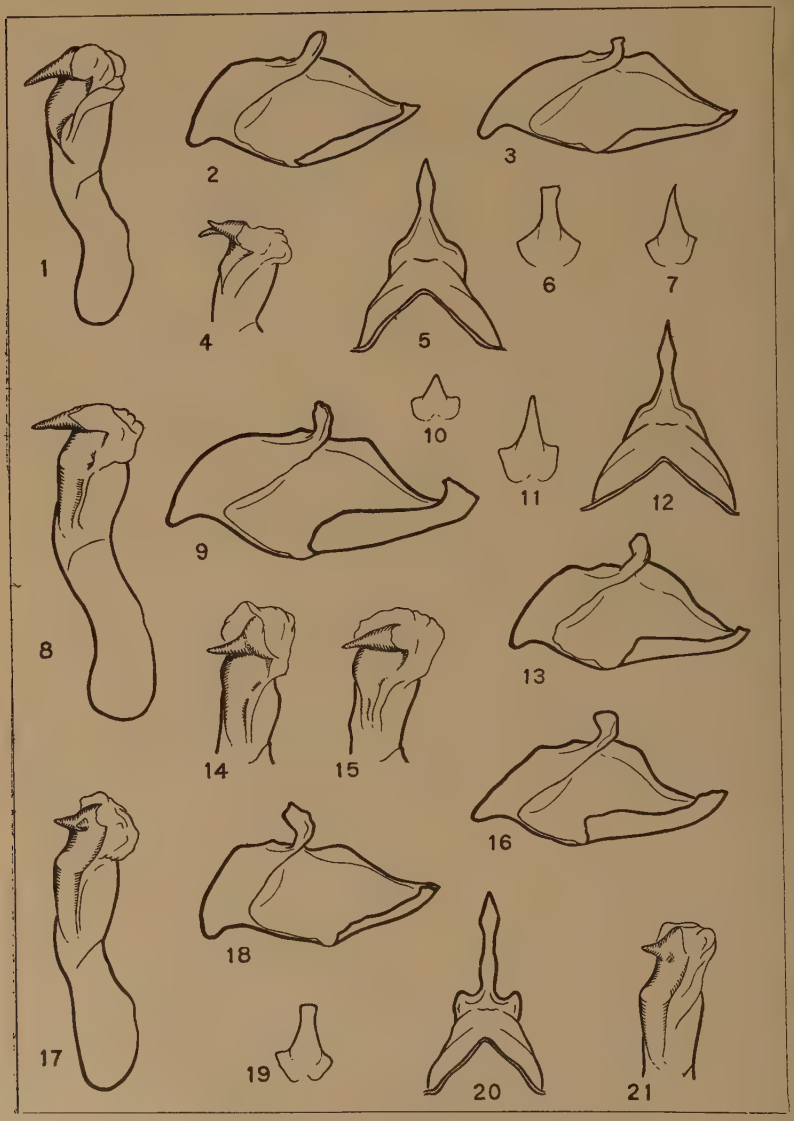
The left clasper is shown, as seen from its inner surface. The uncus, attached to the dorsal half of the tegumen, is seen from above; the uncus is more heavily outlined. The juxta is seen from below. The right lateral aspect of the ædoeagus is shown, the dorsum to the right. Drawings were made with camera lucida; all are to the same scale.

Figs. 1-7, *A. nais.*
1, ædœagus. 2, clasper. 3, clasper, variation.
4, ædœagus, aberration. 5, uncus. 6-7 juxta, variations.

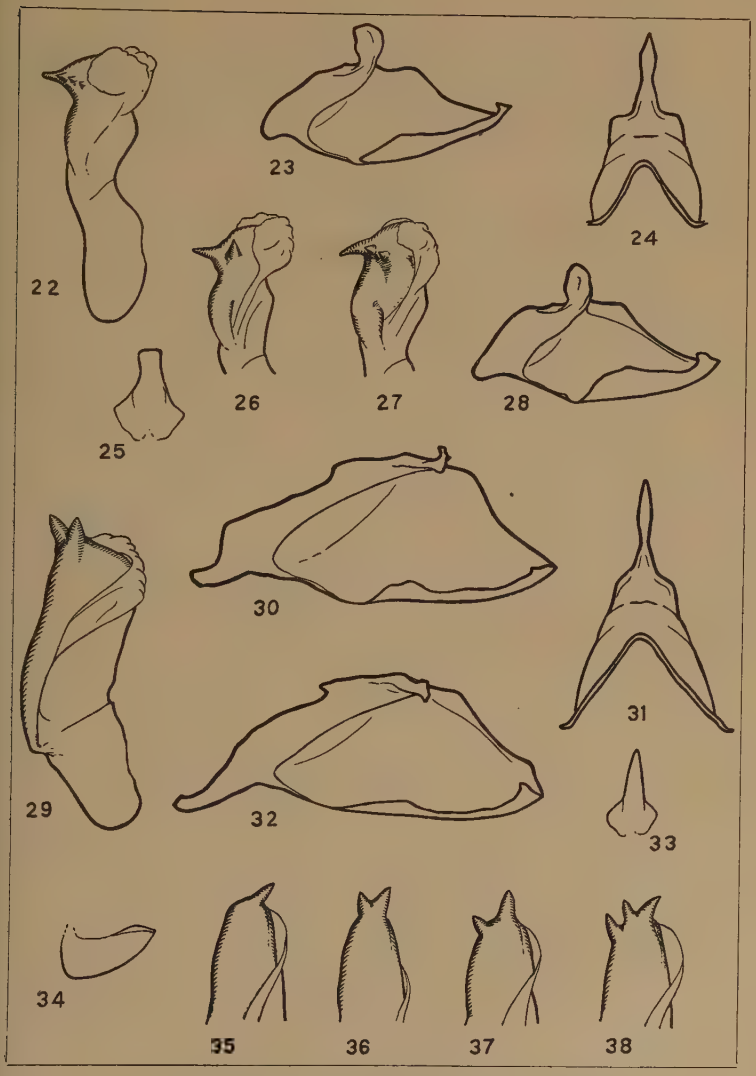
Figs. 8-21. *A. vittata.*
8, 14, 15, normal forms of ædœagus. 10, 11, juxta.
12, uncus. 13, clasper. 9, 16 claspers, variations.
17, 21, ædœagus of aberrant form. 18, 19, 20, clasper, juxta and uncus of aberrant form.

Figs. 22-28, *A. radians.*
22, 26, 27, forms of ædœagus. 23, 28, claspers.
24, uncus. 25, juxta.

Figs. 29-38, *A. phalerata.*
29, ædœagus. 30, normal clasper. 31, uncus.
32, clasper, variation. 33, juxta. 34, lateral view of juxta. 35-38, variations of ædœagus, (ventral aspect).



LEARNED—NAIS - GROUP OF APANTESIS



LEARNED—NAIS - GROUP OF APANTESIS

PRELIMINARY EXPERIMENTS FOR THE CONTROL OF CERTAIN EUROPEAN VINE-MOTHS BY FUMIGATING WITH CYANOGAS CALCIUM CYANIDE.[1]

By S. M. Dohanian,
Somerville, Massachusetts.

In western Europe there is no fruit cultivated as extensively as the grape. Travelers there are at once impressed by its general culture. Vineyards are exceedingly common in Portugal, Spain, Italy, France, Switzerland and western Germany, the parts of Europe with which the writer is familiar. It is natural, of course, to assume that a plant as common as the grapevine must have a large number of insect enemies. And it has. There are more than a dozen insects which may be considered of economic importance. The most notorious of them all, however, are two small Tortricids, commonly known in Europe as Cochylis (*Clysia ambiguella* Hb.) and Eudemis (*Polychrosis botrana* Schiff.).

Records show that for more than two centuries these two pests—and they are pests in the full significance of the word—have been present in the vineyards of Europe. Over a period of many years the annual loss to the vineyardists in each of the countries mentioned above has been millions of dollars. Owing to this enormous damage they have been the subjects of study by various noted entomologists in these countries, but till now no effective method of control has been discovered.

The investigations of the writer in the winter of 1925-26 brought forth the interesting information that thse two insects are unable to survive a dry season. While he was in Spain during the spring and summer of 1924 he was witness to a severe drought lasting from mid-April to late that autumn. This dry spell had reduced their numbers more than 95% for the season of 1925. The month of January, 1926, was spent in an exhaustive

[1] In November, 1925, the American Cyanamid Sales Co. of New York, sent the writer, who was then in their employ, to Europe to investigate the possibilities of Cyanogas calcium cyanide being used for the control of the vine pests mentioned in this article.

survey of the country for an infestation where methods of control with calcium cyanide could be studied, but without success, for the infestations throughout the country had been reduced to a minimum.

European entomologists have uncovered a formidable array of natural enemies during their constant studies of these two pests. There are recorded some forty hymenopterous parasites of the eggs, larvæ, and pupæ common to both pests. They are also frequent victims of several fungi and bacterial diseases. The annual loss occasioned by the two pests, despite these natural enemies, has always been enormous, for which reason many efforts at artificial control have been attempted.

One of the most promising artificial control measures was that attempted on a small scale by Dr. Friedrich Stellwaag of Neustadt a/d Haardt, Germany, in 1917-1918.[2] He conceived the idea of fumigating the vines with HCN gas by the use of sodium cyanide and sulphuric acid under cover, because of the success this method had produced in the California citrus groves. His preliminary experiments, well planned and thoroughly executed, were carried on between April 24 and June 12, 1917. In April the fumigations were made on the leafless vine stalks (winter condition) and in June they were fumigated in their summer condition. The results obtained in Dr. Stellwaag's experiments may be briefly summarized as follows: 1. Fumigation of the plants in their leafy (summer) condition, even when only small quantities of the gas are used, cause damage to the foliage without completely killing the pests. 2. On the other hand the vines in their leafless (winter) condition are able to withstand larger quantities of the gas, sufficient (under the conditions of the experiment) to kill the cocoons found under the tent in which the fumigation was done.

The results of his 1918 tests[3] checked substantially with those of the previous year, except that more injury to the vines was noted due to rapid formation of the gas. Furthermore, Dr. Stellwaag believed that this form of fumigation was "too fussy,

[2] "Der Weinbau der Rheinpfalz," No. 8, August 1917.
[3] "Der Weinbau der Rheinpfalz," No. 1, January, 1919.

too expensive and unreliable." Therefore he discontinued further experimenting along these lines.

With the development of calcium cyanide during recent years, it was believed that these objections were eliminated. It is a product convenient to handle, easy to apply, less dangerous, and much more economical. Its greatest asset, how-ever, is that the gas is not evolved suddenly and turbulently. When normal dosages are applied the chance of injury to living plant tissues is at a minimum, for the gas evolves gradually, the peak being reached some little time after the plant tissues have received small amounts of the gas produced soon after application. In the firm belief that calcium cyanide would succeed where the old process of sodium cyanide plus sulphuric acid had failed, the writer was sent to Europe in December, 1925, to investigate the possibility of control of Eudemis and Cochylis with Cyanogas calcium cyanide.

As mentioned above, no adequate location could be found in Spain, due to the scarcity of the pests in that country. However, two suitable sites were found, the first being near Bordeaux, France, the other in Lausanne, Switzerland. Dr. J. Feytaud, director of the Station Entomologique de Bordeaux, very kindly co-operated in the undertaking by allowing the use of his laboratory facilities and also permitting us to experiment in vineyards under his charge. Similarly, Dr. H. Faes, director of the Station Fédérale d'Essais Viticoles de Lausanne, courteously extended the use of laboratory and vineyards. Both thus facilitated the experimental work.

Life Histories of the Pests.

Before proceeding with the details of the experiments it is well to mention briefly the salient features in the life histories of these insects. Essentially they are alike, the only variation being that *Clysia ambiguella* (Cochylis) has two annual generations, whereas *Polychrosis botrana* (Eudemis) has sometimes a partial and sometimes a full third generation. Both insects pass the winter as pupæ within rather thick cocoons spun by the larvæ. The cocoons are ordinarily attached to the vine stalks, although at times they have been found on rocks, fences, the

wooden supports placed beside the stalks, and other similar objects. In seeking locations for hibernation the fullgrown larvæ instinctively select such sheltered and secluded spots, in which to spin their cocoons, as will insure complete protection against the elements during the long hibernating period. Consequently the cocoons are to be found in the folds of the bark, in crevices, holes, fissures, cracks, etc. The newly formed cocoons of Eudemis are clean and snow-white; whereas those of Cochylis are invariably covered with dirt, dust and debris of all sorts, making them difficult of detection.

The adult moths emerge late in April or early May, simultaneous with the bursting of the buds, and are present thereafter until early in the fall. The Cochylis adults are nocturnal in habit, while those of Eudemis are more active at dawn and at dusk of day. The females, after fertilization, commence laying their tiny and solitary eggs in the flowers of the host plant. These eggs hatch in from 7 to 30 days. The larvæ of the first generation attack and destroy the flowers, while those of the following generations damage the fruits. The second generation adults of Eudemis appear about the third week of June (a cycle of 7 weeks) while those of Cochylis do so towards the middle of July (a cycle of 9 weeks). Thus it will be seen that from early May until cool weather stops their activities (late September) all four stages of these insects may be found in the field.

The Experiments

The aggregate damage caused annually by these insects is enormous. The idea was also gathered from entomologists interviewed that no difficulty would be experienced in locating heavy infestations. In view of these facts it was the original intention to experiment with Cyanogas calcium cyanide for the control of the pests by treating the infested vines without disturbing or removing the insects from their natural hibernating quarters. However, when the actual work was begun the plans were changed to suit the work to existing conditions. Bushels of bark were peeled off the vines in a number of infested vineyards within close proximity of the two laboratories, and all cocoons of

the two pests were then removed from them in the laboratories. In detaching them from the bark many of the cocoons tore open, for they were attached very firmly. About 700 cocoons of the two species were recovered from about twelve bushels of peeled bark.

For their treatment with calcium cyanide, the insects (cocoons) were retained in a coarse muslin suspended on the stalks fumigated. No pupæ were used in the experiment which failed to respond to a gentle pinch with the forceps, prior to fumigation.

The vines.—The vines treated in Switzerland were of a species called "chasselas," indigenous to that country, while in France vines with American rootstock were selected. Vines of varying ages, from 5 years to 50 years, were treated in order to secure information concerning the resistance of plants of varying ages to the action of HCN gas.

In Switzerland the majority of vineyards are of the type where the vines are grown singly, trained on wooden supports about 1 meter or a little over in height, placed in the ground close to the pruned vine just as soon as growth begins in the spring. The French methods of cultivation are of three types: (1), individual vines (as in Switzerland) pruned close to the ground; (2), vines trained on a single line of wire stretched the full length of each row; and (3), taller vines trained on double lines of wire, the first line about 30-35 c. m. above the ground, and the second wire about an equal distance above the first. The wires are attached to strong wooden posts in the rows, placed about 12-15 meters apart. The majority of vineyards in France are of the third type.

The covering.—The protection afforded the insects by their heavy covering (the cocoons) and also the fact that their respiratory system is at the minimum period of functioning during this season of the year (late winter and early spring) and stage of their life, made it at once evident that open air fumigation would be futile. Consequently a canvas tent and a cylindrical galvanized iron can were used in covering the vines for the treatments. The tent, of heavy impermeable canvas, was made large enough to permit treatment of four vines together. Its

dimensions were 1.25 m. x 1.25 m. x 0.65 m. On its four sides a flap 12 c.m. wide was planned to insure against leakage of gas during fumigations, by placing earth or stones or other weighty materials on the flaps. The galvanized iron can was 95 c.m. high with a diameter of 60 c.m. The galvanized iron can was originally thought of because of the certainty of its being airtight and rain proof, very important considerations for overnight fumigations. It has the further advantage in winter fumigation work over the canvas tent in that the temperature within it rises several degrees above that of the outside air. Tests made to determine this point showed an increase of 2 degrees C. after an exposure of one hour, when the outside temperature was 10 degrees C. and an increase of 5 degrees C. after an exposure of two hours with the outside temperature at 16 degrees C.

Dosages and exposures.—The cubic content of the tent was 940 litres. In order to secure a concentration of HCN gas equal to 1% of the volume of the space within this tent, it was calculated that approximately 45 grams of $Ca(CN)_2$ should be applied. For a dosage of 10% volume, therefore, it would be necessary to use ten times 45 grams, or 450 grams. Likewise it was found that 12.5 grams of $Ca(CN)_2$ would produce a 1% volume concentration of HCN gas when applied under the galvanized iron can, the cubic content of which was 270 liters. The dosages used in the 71 experiments varied from 0.275% volume to 10.00% volume, each dosage being tried at least twice with a given exposure. The exposures were varied also, these being dependent on the dosages. The exposures were for periods of 30 minutes, 45 minutes, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ and 3 hours. Some overnight exposures were also tried. In general, smaller dosages were used in the long exposures and larger dosages in exposures of short periods.

The treatments.—Dr. Stellwaag, in the experiments referred to above, found that the grapevine is an extremely delicate and tender plant and that it is unable to withstand heavy concentrations of HCN gas. In view of this, coupled with the desire to cause as little injury as possible to the plants, the dosages used in the first twenty experiments were less than 1% volume. Beginning with a dosage of 0.275% volume, with an exposure

of 30 minutes, both dosage and exposure were increased to 1% volume and treated one hour, but witn no appreciable effect on the insects or on the plants. Gradually the dosages were increased even beyond that fatal to the insects up to 10% volume to note the effect of abnormally strong applications of HCN gas on the vines. It is interesting to note that even such a heavy dosage as 10% volume (450 grams to a space of 940 liters) just before the flow of sap had commenced (on March 25, 1926) did not prove fatal to the plants, merely "retarded growth" being the observation made on the following 12th of April.

In all the experiments fresh Cyanogas calcium cyanide grade "A" dust was used. The exact dosage of the dust, after being measured on balance scales, was placed in a foot-pump duster and applied under the tent or galvanized iron can. No difference was noted in the results when the nozzle of the duster was directed to the bottom of the covering or to its top. In the latter case the plants would be covered with a fine coating of the dust, whereas when the dust was directed to the ground there would be practically no dust on the vines. In either case the effect both on the insects and the plants treated was the same.

To discuss each of the 71 experiments in detail seems unnecessary, for the majority resulted in only partial kills or no kills at all. Only in nine of the experiments was complete kill of the insects exposed to treatment secured, the details of which are given in the accompanying table.

The primary object of Experiments 29, 30, 31 and 32 was to see if abnormally excessive dosages, during exposures of 30 and 45 minutes, under the tent and also under the galvanized iron can, would be fatal to *the vines*. Observations on the condition of the plants made on April 12, a short while after the leaf buds had burst, showed them to be slightly retarded in growth. No injury was caused to any of the plants in their dormant condition even with such strong applications of the poison.

Experiment 53 was conducted on a fair, warm and calm afternoon. 15 naked pupæ were exposed to 3.5% volume (45 grams of poison to 270 liters of space) for one hour, from 2:15 to 3:15 p. m., under the galvanized iron can. The nozzle of the

Exp. Number	29	30	31	32	33	53	55	57	59
Date	3–25	3–25	3–25	3–25	3–26	4–5	4–5	4–6	4–6
Hour[4]	3:03 P.M.	3:15 P.M.	3:59 P.M.	4:08 P.M.	7:32 A.M.	2:15 P.M.	3:23 P.M.	2:30 P.M.	4:33 P.M.
Sun	Yes	Yes	No	No	Hazy	Yes	Yes	Yes	Yes
Clouds	No	No	partial	partial	light	No	No	No	No
Wind	Weak	Weak	slight	slight	calm	No	gentle	calm	calm
Temperature[5]	54° F.	57° F.	55° F.	55° F.	44° F.	61° F.	63° F.	61° F.	64° F.
Relative Humidity[5]	59%	55%	54%	54%	78%	54%	54%	51%	47%
Exposure	45 min.	45 min.	30 min.	30 min.	45 min.	1 hr.	3 hrs.	2 hrs.	1½ hrs.
Dosage	450 gr.	125 gr.	450 gr.	125 gr.	225 gr.	45 gr.	25 gr.	32 gr.	38 gr.
Rate	10% vol.	10% vol.	10% vol.	10% vol.	5% vol.	3.5% vol.	2% vol.	2.5% vol.	3% vol.
No pupae treated	10	10	10	10	9	15	11	5	6
% pupae killed	100%	100%	100%	100%	100%	100%	100%	100%	100%
Effect on vines	retarded growth	growth retarded	none	much retarded	none	a little retarded	none	none	none
Covering	Tent	G. I. Can.	Tent	G. I. Can.	Tent	G. I. Can.	G. I. Can.	G. I. Can.	G. I. Can.

[4]Beginning of treatment.
[5]At start of fumigation.

foot-pump duster was directed upward, and at the termination of the treatment it was noted that the powder was very uniformly distributed over the ground and lightly over the plant. All of the pupæ were dead when examined 42 hours after fumigation.

In Experiment 55, eight naked pupæ and 3 pupæ in cocoons were treated for 3 hours (3:23 to 6:23 p. m.) on April 5. Only 25 grams of calcium cyanide was used (2% volume). The temperature at the beginning of the experiment was 63° F. and 59° F. at the end; and the relative humidity went up from 54% to 57%. There was a gentle breeze present, but really without effect since the treatment was under the galvanized iron can. There was again a uniform distribution of the dust on the vine and the ground. When examined on the 7th of April all the naked pupæ were dead and those in the cocoons were stupefied. They never recovered, for on April 10 the three pupæ in cocoons are recorded as being also dead.

Another combination of dosage and exposure, under similar atmospheric conditions and fatal to the insects treated, was found by the test under Experiment 57. Here five cocoons were fumigated under the galvanized iron can for two hours with a dosage of 2.5% volume (32 grams to the 270 liters of space). The temperature rose from 61° F. at the beginning to 64°, and the relative humidity dropped from 51% to 47%. When examined 48 hours after exposure all five pupæ in cocoons appeared stupefied, while three days later they were pronounced dead.

Perhaps what may be considered the best combination of dosage and exposure was that revealed by Experiment 59. On April 6 one naked pupa and five in cocoons were treated under the galvanized iron can from 4:33 to 6:03 p. m. 38 grams of calcium cyanide (3% volume) were used in this experiment. The temperature varied from 64° F. to 59° F. and the relative humidity was between 47% and 57%. The day was fair, clear and calm. Forty hours after the treatment the insects were found dead upon examination.

In all the remaining experiments mortality varied from none to 82%. The following chart illustrates the combinations of

dosage and exposure resulting in 100% mortality to the insects when accompanied by favorable climatic conditions, as shown by these tests.

EXPOSURES (in hours)

DOSAGES (in % volume)	½	¾	1	1½	2	2½	3	
1%								
1.5%								
2%							X	
2.5%					X			
3%				X				
3.5%			X					
4%								
4.5%								
5%		X						

(Note: x signifies 100% kill of insects fumigated; e. g., a 3% volume treatment for a period of 1½ hours resulted in a complete kill of the pupae exposed to the treatment.)

The following conclusions are presented only because they throw some light on the possibilities of the use of calcium cyanide for the control of these pests. However, it must not be forgotten that they are the results of only a few preliminary experiments.

CONCLUSIONS

1. Treatments of Cochylis and Eudemis with dosages between 2% volume and 3.5% volume during exposures of from one to two and a half hours give better kills than stronger dosages over shorter exposures, or weaker dosages over longer periods of fumigation.

2. Temperatures above 60° F. appear to be more effective.

3. High relative humidity does not appear to be so important a factor as high temperature.

4. A metal covering over the vines gives much better results in the number of insects killed than a canvas covering, under identical conditions. This appears to be due principally to two factors; (1) A metal covering is more air tight; (2) the temperature in a metal covering is higher after a certain exposure than it is under a canvas tent under a like exposure.

5. In the winter dormant condition vines are not injured by the use of Cyanogas calcium cyanide. Both young and old vines seem to withstand with safety such strong treatments as 10% volume for 45 minutes.

NOTES ON THE MITE *PEDICULOIDES VENTRICOSUS* NEWPORT.[1]

Raymond L. Taylor.

The mite *Pediculoides ventricosus* Newport, attracted my attention when it completely destroyed several hundred parasites, which I was rearing. This acarid has been described as both beneficial and noxious, but this difference of opinion appears natural when one considers its wide range and the large number of insect species which it attacks. Moreover, it has been definitely shown to cause an irritating form of dermatitis in man.

Pediculoides ventricosus was observed by Newport in 1849 in the nests of *Anthophora retusa* at Gravesend, England, and was described by him in a published record in 1853. In 1879, Geber observed in Lower Hungary an eruptive epidemic coming from barley, and his investigations showed an acarid responsible for the dermatitis. Webster says that it would seem quite probable from Geber's illustrations, that the mite involved in the epidemic might have been *Pediculoides ventricosus*. The mite was first recorded in America in 1882 by Webster, who held that it had probably not only occurred as early as 1830 in Massachusetts, but it had also, at that date, become noxious to man. Harris in the second edition of his "Insects Injurious to Vegetation" refers to an observation he made in 1844 at Cambridge, that straw bed ticks had proved very troublesome to children sleeping on them because of insect bites. Harris ascribed the bites to *Isosoma hordei*, but Webster believes that it is more likely that *Pediculoides* was the cause of the dermatitis. Since 1884, many notes on the attacks of the mite upon both man and insects, have been made.

Pediculoides is widely distributed. It has been reported throughout the United States and Canada, especially in the regions where grain is grown, in virtually all of Europe, parts of Africa, notably Egypt, and in India.

This mite feeds principally upon larvæ and pupæ of such a

[1]Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 285.

great variety of insects, that a complete list would be very difficult to give. It occurs most abundantly, however, in connection with cereal insects such as, *Sitotroga cerealella* Oliv., *Sitophylus granarius*, Linn., *S. oryza* Linn., and notably, *Isosoma* species, all of which are greatly checked. It also feeds upon the parasites of these and of other insects and would, probably, feed upon any insect that was unable to escape. Because it controls the depredations of many destructive insects, *Pediculoides* has been considered beneficial from an economic standpoint.

In contrast to this view, the mite has been considered noxious, principally, because it causes a disagreeable, eruptive dermatitis, which is accompanied by a severe itching. If enough lesions are made, the person afflicted will have other symptoms, such as a rise in temperature, an acceleration of the heart rate, intense headache, anorexia, nausea, and diarrhœa. Such cases occur in the harvest fields of the Middle West, and in grain elevators, warehouses, and farm homes that have fresh straw mattresses. Here the mite is associated, of course, with the cereal insects mentioned.

In my opinion, *Pediculoides* is noxious to a degree as yet not realized, for another reason, and that is, its destruction of parasites. It has been widely observed that parasites of a great variety of insects are attacked by this predaceous mite, but it appears that these facts have not been stressed. Parasites reared in cultures in the laboratory are very commonly completely destroyed. Lichtenstein in France in 1863 stated that he could not for six months, breed a single specimen of Hymenoptera, while Buprestids, Cerambycids, and some Lepidoptera were also completely destroyed. Berlese cites the fact that Newport was forced to abandon the rearing of hymenopterous larvæ, while Essig mentions that in the rearing of hymenopterous parasites for the control of scale insects in California, the mite not only destroyed all the parasites in some insectaries, but also attacked the attendants.

My own experience follows:—The prepupæ of *Eurytoma pissodis* Gir., a hymenopterous parasite of the white pine weevil, *Pissodes strobi* Peck, were dissected out of the larval chambers

of the weevil and placed in rearing tubes of glass, closed at one end with plaster of Paris and at the other with cotton. During October and November the prepupæ showed no evidences of attack by *Pediculoides*. In the tubes there was considerable débris, consisting of wisps of wood formed by the weevil larvæ, and particles of decayed bark. Without doubt, mites were in the débris at this time but they were unnoticed. The tubes were kept outdoors until the end of December and were then placed in a greenhouse at a temperature of 60° F. or more, while the prepupæ still appeared perfectly healthy. In mid-January,

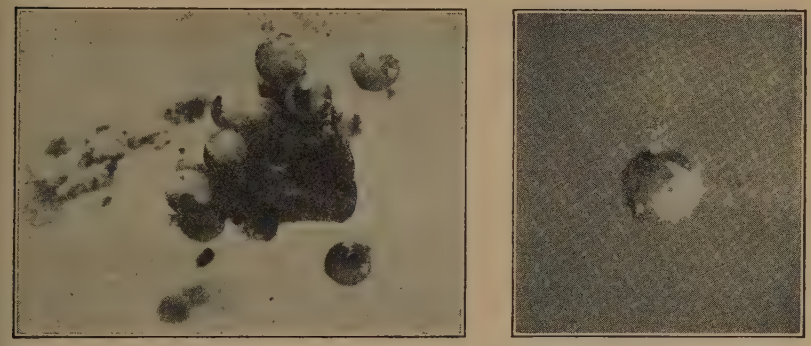


Fig. 1 At left, *Eurytoma* prepupa infested with mites; at right, gravid female of *Pediculoides ventricosus*.

when a number of the prepupæ turned lemon yellow, they were culled from the tubes and isolated. Within three or four days, there appeared upon the surface of each yellow prepupa, one or two characteristic, pale yellow spheres, the abdomens of the mites. Within a week the number had increased to three or four, and at the end of three weeks the number was ten to twenty. From this time, the prepupæ decreased in size slowly, while the number of new mites apparently did not increase as rapidly as before. The figure shows a prepupa after six or seven weeks. It has lost more than half its size and the wrinkled surface is covered with mites. The spheres in the background are the abdomens of mites that have fallen off in the preparation of the material for photographing, since they are easily dislodged

when gravid. The prepupæ left in the tubes eventually passed through the same stages of infestation. The apparently uninfested prepupæ are of a creamy white appearance and often move slightly. No matter how frequently they were transferred to sterile tubes during January and February, all of them were destroyed. Thus, of several hundred prepupæ, only five reached the pupa stage and these, with one exception, died, covered with mites. The exceptional one attained the adult stage but did not live long enough to disengage the pupa skin completely.

It is probable that *Pediculoides* was able to infest a prepupa for several days without any evidence of its presence, since, although each prepupa was brushed and examined carefully before isolation, the mite invariably appeared. It is also probable that a prepupa, at the time of its transference, might have had one or several mites upon its surface which survived the brushing and escaped notice. That this acarid could remain unnoticed, is at least possible, because of its minute size, pale color, and semi-translucency when young. It is also possible that it may penetrate into the spiracles of the prepupa.

Some other parasites of the white pine weevil, namely several Braconids that pupate in pupa cases or cocoons in the larval chambers of the weevil, were not attacked by *Pediculoides*, although they were reared throughout in unsterilized tubes. Whole sections of twigs were in the tubes in this case; much frass and decaying bark was present, yet the emergence percentage was very high. In the material dissected, however, many intact cocoons were found which were shrivelled and which showed that they had been destroyed by some agency which may have been the mite. In other weevil larval chambers, groups of mites were found with remains sufficiently indefinite to defy analysis, although very probably, they were examples of *Eurytoma pissodis* which were destroyed under natural conditions, since abundant evidence, such as no weevil emergence hole in the wood, the size of the twig, and contiguous *Eurytoma* prepupæ, pointed that way. No clear cut case of mite destruction of weevil larvæ was observed, though this proves nothing, since, at the time of dissection, at least three months had elapsed since the weevil larvæ were in the shoots. Several cases of mite destruction of unde-

termined coleopterous larvæ were observed. The mites in the white pine terminal shoots were, in general, most abundant directly under the bark where, in this damp situation, they probably feed upon dipterous larvæ.

A brief description of *Pediculoides ventricosus* may be useful. The males and unfed females are a pale straw color and measure 1-5th mm. and less. The male remains slender, but the abdomen of the female swells enormously, assumes a spherical form, and attains a diameter of nearly 1 mm. Through the virtually transparent body wall of the abdomen, the contents, which are rather thin in consistency, appear the color of the yolk of a hen's egg or lighter, with amorphous masses of a milky white substance throughout the yellow, though these are usually more or less localized. This amorphous white substance appears to be connected with the soft, rather globular eggs, which may be readily observed and counted. From two to thirty eggs have been observed in progressive stages of development, though Webster has counted forty to fifty. In mites that have been in dry surroundings, and perhaps in general, in the case of older mites, the yellow substance is thicker on one side of the abdomen and assumes a dark brown color.

The life history of *Pediculoides* does not seem to have been completely worked out. Newport, who observed it in 1849, believed that the species was parthenogenic. Webster, in 1882, was inclined to agree with Newport, although he states later that he has noticed an occasional male. In this early paper, Webster says that the young not only hatch within the bladder-like abdomen but attain their full development there, and are liberated as they are developed. In breaking up the abdomen of the female, I have observed young mites crawling out of the fluid contents. Essig, in his text, "Insects of Western North America," adds that *Pediculoides* mates soon after birth. Under favorable conditions they increase rapidly. When feeding, they crawl about upon a larva or a pupa, often puncturing the skin within a few minutes after discovering the prey, and then they more or less continuously suck the juices. It is interesting to note that the prepupæ observed moved violently when a mite was placed upon them, but ceased the alternate curling and

straightening within a minute, and then repeated this behavior several times within an hour. The females, which form a large majority of the individuals apparently tend to remain attached to the original puncture till distrubed, their abdomens swelling to a size 10 to 50 times that of the cephalothorax. If the prey is fresh, the mites are aided in their attachment by the adhesive quality of the fluid that issues from the punctured body. If brushed off they will puncture in the next place at which contact is established, although their mobility decreases, of course, with their growth. As seen in the figure, the mites appear as globular excrescences upon the surface of the infested larva or pupa, since the cephalothorax is hidden by the enlarged abdomen and may be more or less intruded into the body of the host.

Control of *Pediculoides*, natural or otherwise, has not been worked out and references to its control are very rare in the literature. That it has some natural enemies seems probable, because without some check, and with its capacities for increase and for destruction of insects, it would soon become more conspicuous. Under natural conditions in the white pine leaders, however, this acarid is not found in every part of the shoot, and in this fact lies the explanation of how a certain number of parasites may survive.

In conclusion, I offer the suggestion that *Pediculoides ventricosus* is more of a factor in economic entomology than is realized. Beneficial in checking cereal insects, it is not a completely welcome agency there, as it may seriously impair the efficiency of the harvest hands and other grain workers. Apart from this, it probably does more harm than good, all things considered, as it destroys parasites that have many times its own predatory power in controlling injurious insects. A compilation of tests for the purpose of ascertaining whether the mite prefers parasites in dead wood and straw, or whether it prefers wood-borers and stem-borers in material which is fresher or not entirely dead, and has less decaying bark, would be interesting.

Abstract.

The mite, *Pediculoides ventricosus* Newport, is beneficial in destroying cereal insects, notably *Isosoma* species, and others.

It is noxious in causing dermatitis in man. The writer has lost several hundred hymenopterous parasites of the white pine weevil—as have others in rearing various parasites. The sug- suggestion is made that the mite is more harmful than realized, as the parasites it destroys probably would kill more injurious insects than does the mite.

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THE OCCURRENCE OF THE PAVEMENT ANT (*TETRAMORIUM CÆSPITUM L.*) IN BOSTON.

By William Morton Wheeler.

The common European pavement ant (*Tetramorium cæspitum* L.) must have been introduced into the United States during colonial days, if Marlatt is correct in supposing that it is the ant referred to by Kalm in his "Travels" in 1748 as infesting houses in Philadelphia. It has certainly been established for many years in the vicinity of Philadelphia, New York City, in New Jersey, on Long Island and in Maryland (Washington and vicinity). I have often found it in Westchester County, N. Y., nesting under stones and occasionally storing small seeds in the chambers of its nests just as it does in various parts of Europe and North Africa. (See Donisthorpe's "British Ants, 2nd Ed. 1927, p. 195). As this ant is very common and prolific over an enormous area in the Old World, from England to Japan, and is represented by certain subspecies as far south as British East Africa and Cape Colony, it is difficult to understand why its spread in the United States has been so slow. This may be due, perhaps, either to the animosity of our native ants or to the enmity which seems so commonly to exist between any two *cæspitum* colonies as to lead to frequent deadly battles between them.

Apart from a few specimens taken in Springfield, Mass. and sent me by Mr. George Dimmock, I have seen no record of the pavement ant from New England. More than twenty years ago I found it abundant at White Plains and Mamaroneck, N. Y., near the Connecticut boundary. Since that time it may have entered the southern portion of that state and have moved up the valley of the Connecticut River as far as Springfield.

On two successive evenings, those of Jan. 19 and 20, 1927, which were very mild and followed a cold spell, I was surprised to find the heated and electric-lighted vestibule of an apartment building (101 Chestnut St.) in the heart of Boston, alive with ants celebrating their marriage flight. They were soon recognized as males and females of *T. cæspitum*, and had issued from

a crevice in the floor near their nest which was situated in the outer masonry of the building. A number of workers were still running about the crevice from which they had permitted their voluminous sexual forms to escape. The apartment building surrounds a court containing a garden. Probably the ants had lived in the soil of this enclosure till the advent of cold weather and had then migrated into the vestibule. At any rate they were here able to bring their sexual forms to maturity and to stage their nuptial flight at a most unusual season, for the normal marriage flight, according to European observers, occurs in July, or at least sometime between June and September. Since the apartment building is very near the Charles River it will be interesting to determine whether the ants may not be spreading from the parked esplanade which borders the river in that part of the city.

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A regular meeting of the Club is held on the second Tuesday of each month (July, August and September excepted) at 7.45 p. m. at the Bussey Institution, Forest Hills, Boston. The Bussey Institution is one block from the Forest Hills station of both the elevated street cars and the N. Y., N. H. & H. R. R. Entomologists visiting Boston are cordially invited to attend.

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